A microfilm looks into the workshop of life.

THE GOD OF THE AMOEBAE

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NOT long ago an amazing film was shown to a small group of people. It is a microfilm produced by the late Hamburg scientist Dr. Arthur Arndt. Its stars are the *Dictyostelium mucoroides* and tens of thousands of little amoebae, and the story told by it is that of the sacrifice and death of these amoebae and the transformation of their bodies into something like a plant.

ANIMAL OR PLANT?

Dictyostelium mucoroides is the botanical name of a low organism related to the Myxomycetes or slime molds. In the system of animals and plants, this organism occupies a special position, for it is on the border line between animal and plant. It is often to be found on horse or other dung and decaying vegetable matter, and it can easily be cultured on an artificial medium. The true slime molds represent "primitive organisms" consisting of naked masses of protoplasm. In the form of a slimy mass, they often cover decaying matter on the forest floor. They are frequently of a brilliant red, yellow, or blue coloring. The largest of them reach a size of 30 centimeters in diameter and sometimes cause trouble in tanneries and gardens. The slime molds consist of two parts: a slimy mass of protoplasm termed the plasmodium, and the spore-containing structures (sporangia). At the reproductive stage, the sporangia grow out of the plasmodium. The spores are formed by part of the living substance of the plasmodium organizing itself into individual cells which surround themselves with a cellulose wall.

All this may seem very peculiar and interesting, but it is simple and quite ordinary in comparison to what happens when the *Dictyostelium mucoroides* is formed. For here what appears to be a miracle takes place, namely, that a large number of tiny animals. amoebae of a certain type and way of living, grow together into a new, uniform plant organism of an entirely different type. Many thousands of amoebae go to form this plant organism, whose origin is in no way apparent to the observer.

The film showing the transformation of life begins.

Enter first *Dictyostelium mucoroides*, the complete slime mold. From its sporangium, spores are just being discharged. They are placed on the nutrient medium, a surface covered with fodder bacteria. Upon touching the nutrient medium, the spores flow apart and distribute themselves equally over the entire surface. And now a strange thing happens: the many thousands of spores begin to swell up. They visibly change their shape. Their breadth increases in comparison to their length. A rhythmical movement becomes apparent in the bodies of the spores. Gradually the contents of the spores become lighter in color. At one of their poles, a narrow slit opens, and—this is a breathtaking sight—a tiny animal, an amoeba, quickly wriggles out of it.

BIRTH AND DANCE OF THE AMOEBAE

Amoebae are protozoans (unicellular animals) and among the simplest known forms of animal life. It is often said that they are nothing but "little balls of naked protoplasm." However, this is a rather superficial view, for actually the protoplasm body of which they consist already possesses a fine structure. We are able to study all the traits characteristic of a living creature in the amoebae. They have metabolism. They creep toward their food by extending and withdrawing portions of their body formed according to requirements. They propagate by division. The amoeba *Vampyrella spirogyrae*, which lives on a certain type of alga, attacks the latter, dissolving its cellular wall at the point of contact, and sucks up the foreign protoplasm. It refuses any other food, even if it is placed in its way in an experiment: it is very particular in selecting its food. In certain circumstances these tiny animals produce surprising achievements which are even regarded as the expression of a certain "intelligence" by some scientists.

Well, to return to the amoebae born from our slime mold: immediately after their birth they begin, in their curious streaming movement, to crawl over the surface in search of food. Soon there are tens of thousands of amoebae. The plant casing from which they were born, the spore covering, remains in the form of two slightly gaping shells.

The birth and swarming of the amoebae lasts for many hours. Their sole longing is for food. Each tiny creature follows its own path, which is determined by the food particles it finds. It absorbs food, grows, divides, and propagates. It seems as if each tiny animal has its own free will. There is no force that rules them, no law or order that influences them. The whole surface is a chaotic crush of amoebae, a seemingly meaningless shuttling back and forth of completely egoistic animals.

THE MAGIC COMMAND

But suddenly a "transcendental" command rings out. A magic outside power interferes in the life of the little egoists. An organizing force seems to operate from somewhere. This happens at the instant in which the fodder bacteria are eaten up.

It looks as if the shadow of a wave were then running across the amoebae, like a sudden gust of wind blowing across a smooth sheet of water or a corn field. The first, hardly perceptible motion is soon followed by several more. If with the first wave it was still doubtful whence it came and, whither it was directed, the following, stronger waves reveal quite clearly that they issue forth from certain centers located approximately in the midde of the amoeba mass. From these invisible operational centers, wave upon wave runs in a rhythmical series across the amoebae in various directions. Sometimes they overlap. Stronger and stronger, more and more agitated grow these strange waves. And finally a rhythmical movement appears which seizes the entire mass of amoebae.

A force superior to the amoebae has interfered with their individual lives. The rhythm which has taken possession of the amoebae leads them to a definite order. The amoebae group themselves. Processions of amoebae are formed which move—guided as if by magic—toward the wave-emanating operational centers. There they accumulate, conglomerating in hemispheric mounds known as *colliculi*. These grow higher and higher, and at their highest points there then forms a shallow cavity, from which a dark, knob-like shape begins to rise. This knob develops into what is known as the *conus*, shaped like a sugar loaf. One clearly gains the impression that the amoebae streaming from all sides become merged in the growing *colliculus*. Their bodies melt into each other. Individual animals turn into the building material for a new living creature. Gradually the processions of amoebae ebb away. They become less dense and stop entirely. Meanwhile, in the heart of the *conus*, the petiolated generative body begins to form. And this represents the culmination and final meaning of the whole strange process.

ORGANIZATION—FROM THE INVISIBLE

All this happens according to plan, guided by an invisible center. Some of the scenes in the film reveal particularly clearly how the entire process is directed at a definite goal and how unforeseen difficulties in the birth process of the slime mold are easily overcome. One sees, for example, how at a certain point on the nutrient medium three or four different *colliculi* and *coni* are formed on a common amoeba basis. Later, at a certain stage of their development, they separate, moving off in directions which are often the opposite ones to those in which the amoebae are moving. While this is happening, more streams of amoebae come marching on to merge into the basis of the *coni*. Wave upon wave comes rolling on. But suddenly a very amazing thing happens. The last wave of the upper stream does not continue its march toward the basis of the upper *conus* but breaks, virtually explodes before our eyes. The amoebae scatter and turn in groups toward the two nearest *coni*. Moreover, they do not move toward the present bases but right away take the direction toward that point which the two *coni* will have reached at the same moment as the groups of amoebae.

Who or what directs the amoebae? What guides their course in such a way that they take a bearing toward a certain point and keep to that direction?

Tens of thousands of tiny animals unite, systematically and in spite of obstacles, in a new, well-constructed, ingeniously functioning organic whole. It would seem as if the amoebae had some sort of "knowledge" of each other, of their movements and their task. How are they able to

organize themselves for the purpose of the new structure, how are they able to adjust the size of their processions to the size of the *colliculi* and even from the very beginning build up the stalk of the generative body in a size corresponding to that of the final generative body?

The unbiased spectator is bound to gain the impression that, from a given moment onward, the events are directed from outside, or that a uniform will dominates the whole, that it is not a matter of individual processes at this or that point of the field of vision but a total process in which the individual events are co-ordinated. It is as if, invisible yet real, the organism being formed before our eyes already exists as an idea and systematically guides the development of the individual toward the whole. The meaning or the idea of that which is to be, brings about and guides that which is. This may seem strange—but in the final analysis this is true in the case of every creative formation of an organism.

IS IT A MIRACLE?

It is unquestionably the task of natural science to attempt to explain even the most miraculous phenomena of life on the basis of the known laws of nature. But by what known laws of physics or chemistry can we explain the almost incredibly systematic events unrolling before our eyes in the amoeba film, events which definitely do not function automatically or mechanically?

When Dr. Arndt, the man whose eyes were the first to see all this, was questioned as to the causes of the strange happenings, he shrugged his shoulders slightly and said: "The god of the amoebae." This is certainly a curious reply from a scientist to an entirely justified question. Did he speak of a god of the amoebae to explain a "miracle"? With his "god of the amoebae" Arndt made use of a poetic phrase to point to a fact which, though hard to grasp, is apparent in all organic formation, namely, that a whole which is to be created guides the elements from which it will be formed, to turn a chaos into a cosmos.

We can cause and observe such systematic formations of a whole in the most varied ways and even under the strangest experimental conditions.

If one cuts off one leg each from a hundred newts, the loss is regenerated in all the animals, and a new organ is formed in a systematic interplay of the cells guided by a center of reconstruction. The object of this process is the reconstruction of the whole animal. However, the natural "architect" of the newts can hardly have reckoned with such amputations. There are no mechanical causes for such measures which can be comprehended on the physical or chemical plane. For every time the regeneration takes place in a different way. It is creative, and it is guided solely by the "will" or "plan" to restore the whole of the animal. It is the whole which guides the incredibly complicated and mysterious interplay of regenerating forces and substances.

If a worm is cut up into many pieces, each of the pieces is regenerated into a complete animal. All the original pieces differ from each other in shape and size and are taken from different parts of the body. Each regeneration takes place in a different way. It is achieved by different methods. The meaning of the whole guides the process. The goal of the organic whole determines the methods.

THE SOUL OF THE BEES

The poet and natural scientist Goethe, through whose eyes we are again looking at life, knew about these architectural forces of life. He spoke of the "breathing of the spirit, which prescribes the direction for each part and which, by an inherent law, restricts or sanctions every digression." And he sensed this "breathing of the spirit" not only in the regeneration of cells to form an organism, not only in the creative formation of a new organism from seeds born and guided by the supra-individual whole of the hereditary stream, but also in the formation of supra-individual organisms which are manifested, for instance, by "insect states."

That which we call the "bee state" represents an entity of life, an organism of a superior order. The members of this entity form different "castes." Like an organ in a visible organism, each caste is entrusted with a definite function. The instinct of the individual insect is determined by a "we" instinct and is guided with magic power by the "spirit of the whole."

There are females of an asocial species of bee which live solitarily. A number of potentialities combined in these females are in the bee state divided among various groups of individual insects which, if they are left to their own resources, are unable

to maintain even themselves or their species. The whole of the bee state determines the specialized development of the variously shaped individual creatures which are endowed with different instincts and depend upon each other. In each individual there lives the whole, influencing the individual.

As in a living organism, so in the supra-individual organism of the bees, too, a systematic regeneration takes place to serve the whole. This is a very strange fact: when the queen dies, a substitute is immediately raised from among the worker bees. And a corresponding creative process takes place when bee states are formed artificially in which certain types of worker bees are lacking. The individual insects behave like cells, and the castes like organs in an organism of a superior order.

In a surprising, miraculous way, the spirit of the whole, or the "god of the bees," manifests itself: only those members of the insect community which have procreative powers are in charge of the future of the species and the heritage. They endow some of their descendants with characteristics which have only arisen in the course of the development of that particular community of bees and which neither they themselves nor their ancestors ever possessed. They pass on peculiarities and instincts of those castes which are themselves unable to procreate.

The amoebae are the lowest form of unicellular animals. The spirit of the whole is able to combine them in a uniform physical structure. In comparison to the amoebae, the bees are superior creatures with a complicated, multicellular organism. The spirit of the whole is able to unite them only in a supra-individual organism which is not physically connected. And between the amoebae and the bees there are many unicellular organisms which, in so-called cell colonies, form a superior organism composed of creatures that are actually still independent of each other.

In the sea, the corals form colonies branching out in all directions, organisms of a higher order. Within them each polyp leads its individual life; yet it carries on a constant exchange of fluid with all the other polyps. In the case of the jellyfish, too, there is a supra-individual community of life in which each individual creature is specialized like an organ in the service of the whole. Only after long, thorough studies did science discover that these organisms of a superior order consist in reality of numerous individual creatures.

In organic life, there are no limits set to the will toward the whole. In the film of the amoebae it becomes unmistakably apparent as it forms a unity step by step. We see a unity being created. Usually we realize it only afterwards, by analysis.

Perhaps the swarm of amoebae seems chaotic to us only because we regard it from the perspective of the individual amoeba and not from the point of view of the entity being created. The whole into which the amoebae merge does not result from the haphazard movements of the amoebae. On the contrary, the whole into which they merge is the cause of what happens. The future exerts a formative influence on the present. The film proves this. This may seem mysterious and utterly improbable, but there is no other explanation for the process shown in the film.

More than a hundred years ago, K. E. von Baer compared the course of development of individuals with a melody. In a melody the sounds do not follow each other haphazardly. Between the first and last sounds and among all the sounds there is a relationship of order. All the sounds harmonize in the melody. This is the goal. The sounds are the means. The melody is the whole, the sounds are the parts. The amoebae are like sounds, and the organism formed from them is like the melody played by life.

When life forms such entities, it makes no difference—as is proved by the film—whether the parts are from the first connected in a way recognizable to our senses, or whether they are united in the course of their development into an organism of a higher form by a law seizing them invisibly.

That is the way it is: those amoebae are like sounds which arrange themselves into a melody when the leitmotiv is struck by the "god of the amoebae."

Where science ends, music begins. Perhaps the students of life must be scientists and musicians, artists and philosophers in one to be able to sense the secrets of the changing and developing organism and to understand them with reverence.